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TOWARDS A NOVEL TECHNOLOGY TRANSFER OFFICE TYPOLOGY AND RECOMMENDATIONS FOR DEVELOPING COUNTRIES

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Abstract:	<p>Potentially, technology transfer offices (TTOs) can play a significant role in facilitating the successful transfer of technologies and knowledge between universities and industry. Many developing countries are currently developing technology transfer practices within their universities. However, many developing country TTOs operate inefficiently or are ineffective. The sharing of experiences can lead to improvements in this endeavour. Advanced nations can serve as a frame of reference and basis of policy recommendations for developing countries due to the longevity of their technology transfer activities. We issued 234 questionnaires to European university TTOs, of which 54 usable questionnaires were returned. We combine data from these with 19 interviews conducted with university TTO staff from 9 countries in an attempt to create a typology of practices that developing nations could emulate to improve technology transfer in their own contexts. Whilst ultimately a clear typology was not forthcoming, we found some relationship between the dominant focus in the mission statement of developed country TTOs, the activities they undertake, their position within the university governance structure and their level of maturity which may usefully inform the development of TTO practices in developing countries.</p>

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Towards a novel technology transfer office typology and recommendations for developing countries

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Abstract:

Potentially, technology transfer offices (TTOs) can play a significant role in facilitating the successful transfer of technologies and knowledge between universities and industry. Many developing countries are currently developing technology transfer practices within their universities. However, many developing country TTOs operate inefficiently or are ineffective. The sharing of experiences can lead to improvements in this endeavour. Advanced nations can serve as a frame of reference and a basis of policy recommendations for developing countries due to the longevity of their technology transfer activities. The authors issued 234 questionnaires to European university TTOs, of which 54 usable questionnaires were returned. They combine the data from these questionnaires with 19 interviews conducted with university TTO staff from 9 countries in an attempt to create a typology of practices that developing nations could emulate to improve technology transfer in their own contexts. Whilst ultimately a clear typology was not forthcoming, the authors found some relationship between the dominant focus in the mission statement of developed country TTOs, the activities they undertake, their position in the university governance structure and their level of maturity which may usefully inform the development of TTO practices in developing countries.

Keywords:

Developing countries, mission statement, technology transfer office, knowledge transfer, typology

As a developing country moves towards developed nation status, it seeks to transform from a resource-based to a knowledge-based economy (Mowery and Oxley, 1995) through the creation of an appropriate country-specific national innovation system (NIS). An NIS is a system of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Etzkowitz and Leydesdorff, 2000), within which the university is a key element (Ranga, and Etzkowitz, 2013). Whilst the NIS is country-specific, there is an assumption that developed country NISs are, as the products of a 'set of countries', all more advanced, sophisticated and nuanced than developing countries' emergent NISs (as a 'set'). As a result, developing countries regard developed countries as having better practices.

Developing countries have tried hard to build viable, effective NISs to reduce poverty and improve income distribution, and have observed that they need to establish, among other things, good university–industry collaboration (Attia, 2015). Transferring technology (broadly defined to include knowledge and practices for our purposes) from developed countries is a means by which developing countries seek to grow and develop (Nepelski and De Prato, 2015). Shared experiences between developed country technology transfer offices (TTOs) and developing country TTOs can lead to learning and improvements in the latter's own processes of technology transfer to local industry (Weckowska, 2015).

To date, developing countries have sought to adopt practices associated with successful commercial technology transfer from, predominantly, Australian, UK and US universities. This has typically led to the formalization of the intellectual property rights (IPR) of universities and the formation of TTOs (Kloppers et al., 2003). The developing country TTOs have typically adopted a reactive approach to technology transfer (Kruss and Visser, 2017), addressing it on a case-by-case basis as and when opportunities for the commercialization of university-generated research arise. However, several studies have shown that many developing country TTOs operate inefficiently (de Falco, 2015; Oliveira and Teixeira, 2010; Tahvanainen and Hermans, 2011). In the wake of various new IPR legislation, TTOs at universities in developing countries need to undertake strategic, well-

defined, proactive approaches to technology transfer (Kruss and Visser, 2017). They also need to adopt a wider concept of the ways in which universities can create linkages with industry and society in general, beyond the commercialization of research. These practices include relationship building, influencing decision-making through consultancy analysis, and so on. Increasingly, TTOs signal their willingness to engage in these various activities in their mission statements.

Whilst much research addresses TTO performance and the actual processes and activities involved in the transfer of technology (Debackere and Veugelers, 2005; Siegel et al., 2003), there is less research on the antecedent characteristics of the TTOs themselves and their impact on the knowledge transfer process. The need for an understanding of these antecedents becomes heightened in developing countries where even well-understood technologies are often adopted with limited success (Secundo et al., 2016). For this paper, we select the TTO mission statement, the position of the TTO within the wider university governance structure and TTO ‘maturity’ (Secundo et al., 2016) as antecedent characteristics of TTOs. During the emergent phase of TTO development, which many developing countries are now facing, these characteristics are critical. Our purpose is to identify whether there are any discernible patterns of alignment between these three characteristics in developed nation TTOs so that they might be similarly aligned in developing country TTOs, on the assumption that such alignment will improve their practices. We work under the assumption that developed country TTOs as a ‘set’ have better practices than the ‘set’ of developing country TTOs (i.e., we conduct a binary comparison). Ideally, we would take the analysis further to investigate correlations and potentially causation between these antecedent characteristics and TTO performance based on some measure of output. However, as Rossi and Rosli (2014), Molas-Gallart et al., (2002) and Molas-Gallart and Castro-Martínez (2007) point out, it is extremely difficult to capture data on the range of ‘third stream’ or ‘third mission’ activities that universities conduct.¹ Moreover, whilst these are often

¹ The most common IP indicator would be counts of patents and licensing, but ‘[...] it is increasingly recognized that focusing Third Mission activities on IP commercialization strategies would likely lead to universities delivering less value to society (Florida, 1999). Consequently, any approach to data collection and analysis that

channelled through their TTOs, this is not always the case as researchers can undertake such activities directly (e.g., via consultancy projects) (see d'Este and Patel, 2007).

Using novel primary data combining questionnaire responses and interviews with TTO staff in a number of European universities, we find a link between the primary focus of a TTO's mission statement, its position within the university structure and its 'maturity level', and have used this link to suggest a novel typology of TTOs. We suggest that developing countries should emulate these better practices from developed country TTOs to improve their own technology transfer practices.

The next section briefly reviews literature on technology transfer and how it has evolved differently in Europe than in the USA, as this motivates the rationale for our data sample. We also review mission statements and TTO typologies with respect their place in university governance structures. The data and methodology section then follows. In subsequent sections we present our findings and derive recommendations for developing countries from our observations, and present our conclusions.

Literature review

University technology transfer in the USA and Europe

Technology transfer from university to industry has long been a topic for policymakers in the USA and Europe, but since universities in developed countries first established TTOs in the 1980s and 1990s (Lockett et al., 2015), technology transfer has changed dramatically (Siegel and Wright, 2015). Historically, academic research focused on the activities within the USA (e.g., Colyvas, 2007; Feldman et al., 2002). This was especially the case after the passing of the 1980 Bayh–Dole Act increased US universities' efforts to generate revenue via the commercialization of research protected under patenting and licensing legislation. Mowery et al. (2015) suggest that a broad range of university–industry activities are undertaken by US universities (both historically and currently) and that this is perhaps under-recognized in the literature. However, even the annual survey of Third Stream activities

focuses purely on university commercial activities is likely to miss large and important parts of the picture.' Molas-Gallart and Castro-Martínez (2007: 322)

by the Association of University Technology Managers (AUTM) appears to concentrate on monitoring the patenting and licensing activity of US and Canadian universities (Molas-Gallart et al., 2002). A survey on TTOs in the USA found that over 50% had lost money on their academic entrepreneurship operations, with only 16% being self-sustaining (Abrams et al., 2009). Other studies have found that many universities (not just US) lack a culture that is conducive to technology transfer and do not possess the complementary assets necessary for success in technology commercialization (Siegel and Wright, 2015).

Nevertheless, the impact of the Bayh–Dole Act on the commercialization aspect of technology transfer caught the attention of policymakers both in other developed regions such as Europe (Mowery and Sampat, 2004; Geuna and Rossi, 2011) and in developing countries. Again, the focus on the commercialization of university research indicated only a weak, and highly concentrated impact of universities on industry and society. In TTOs across Europe, just 10% of TTOs secured 80% of all licensing deals and the top 2% of TTOs across six countries captured 40% of all licensing revenue (Frederick and Granieri, 2015). Whilst developing country TTOs have similarly adopted practices associated with commercial technology transfer (Kloppers et al., 2003), as the analysis of commercially-focused TTOs in both the USA and Europe show, commercialization processes alone do not necessarily yield the desired results of more technology being transferred from the science base to industrial application.

Compared to the USA, the underperformance of European nations in terms of patents, licensing and spin-off creation led European policymakers to focus on improving knowledge transfer in other ways than commercialization and entrepreneurial spin-offs (Siegel et al., 2007). Simultaneously, the growing literature on the ‘knowledge society’ shifted the analytical focus from technology transfer to the broader concept of ‘knowledge exchange’, also making it more appropriate to consider a wider range of factors than just intellectual property (IP) commercialization. Additionally, higher education institutions faced increasing pressure to demonstrate measurable impacts on business and society to justify the amount of public funding they received (Edwards, 2013). The tighter funding

environment in which universities now operate requires universities to create more dialogue between science and society, and to contribute towards regional development through basic and applied research endeavours, and to the development of human capital and cultural capital for social cohesion (OECD, 2008; Edwards et al., 2014). As a result, the evolution of policy in Europe broadened significantly beyond the commercialization of technology.

European public policies regarding higher education now emphasize the role of higher education institutions in knowledge-based economies (Gonzalez-Loureiro and Teixeira, 2011). The image of universities as ivory towers is being abandoned (Hershberg et al., 2007). As stated by the European Commission (2003), the main goals for universities must be the production, diffusion and transfer of knowledge. These are crystallized in the UK by the Research Excellence Framework (REF), which assesses universities and their departments on their level of international scientific excellence and rewards them accordingly through a funding formula that is biased in favour of the top performers. The REF uses three assessment criteria: research output (publications), environment (support structures and initiatives for research activities), and, critically, *impact* (requiring evidentiary support that university research has actually been adopted by, or influenced thinking in, spheres outside of academia). It is evident that the objectives of TTOs in Europe differ from those that dominate in the majority of studies about the USA.

In their study of Turkey, Ranga et al. (2016) identify the challenges faced by early-stage TTOs in developing countries. These challenges include: low technology- and market-oriented research capacity; institutional obstacles to patenting, licensing and spin-offs; low IPR awareness and spread of IPR policies; and the current IPR regime. Given the lower state of technological development in developing countries, and the generally weak evidence for the technology commercialization objective as justification for public investment in university activities, it is clear to us that developing nations should be encouraged to address knowledge transfer more broadly (as opposed to technology transfer specifically) in the manner adopted by European universities. This includes not only technology commercialization and entrepreneurial activities (spin-outs), but also research collaborations, staff

secondments, curriculum alignment, student placements and dissemination through outreach and public engagement activities (see Molas-Gallart et al., 2002).

Mission statements

Organizations from many spheres (public, private, charitable, industrial, educational, etc.) can benefit from well-defined mission statements. The mission statement guides the organization in strategic, operational, long-term and daily decision-making and, in doing so, binds the multiple parts of the organization into a coherent whole, articulating its purpose. The focus it brings is particularly useful when the organization faces a complex environment (Ireland and Hitt, 1992), such as that which universities increasingly face. The mission statement helps members to distinguish between activities that uphold institutional imperatives from those that do not. In addition to its utility in guiding activities for members of the organization, it also acts as a signal to external actors and agents, which is particularly important given that partnerships and networks are increasingly necessary for the successful operation of today’s organizations (Davies and Glaister, 1997; Morphey and Hartley, 2006). Fitzgerald and Cunningham (2016) summarize three core purposes of mission statements: to be a guide to decision making, to be a communication tool, and to assist in directing the formulation and implementation of strategic planning.

The TTO is the key intermediary between the university and external organizations. Given the breadth of activities through which universities influence industry and society, the TTO’s mission statement and objectives will be determined by the university (Brescia et al., 2016) and can be manifold. Kruss and Visser (2017) have shown that the mission statement of the university can drive or block technology transfer and university–industry interaction. The mission statement must be clear to achieve the benefits identified above; otherwise, it may be perceived as a patchwork of fashionable phrases that are too vague or unachievable, and with which the internal members do not identify (Morphey and Hartley, 2006). Indeed, universities have been criticized for putting everything they can

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3 potentially, and hope to achieve, into their mission statement, leaving little guidance on priorities for
4 decision-making (Morphew and Hartley, 2006).
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7 TTOs, whilst less concerned with the aspects pertaining to the quality of education and
8 teaching of the parent university, still have a variety of potential objectives that could be embodied in a
9 mission statement, and experience the same dissatisfaction from the absence of a clear primary
10 objective. The mission statement should determine which technology transfer activities will be
11 undertaken, and how the success of the TTO will be assessed.
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18 Fitzgerald and Cunningham (2016) have suggested that, during the emergent phase of TTO
19 development (in which many developing countries are currently engaged), understanding and defining
20 the purpose and intent of the TTO is an important, but complex task. Formulating the mission
21 statement requires a multi-linear if not a multi-typological approach. Rossi et al. (2016) state that, in
22 response to market-type incentives, higher education institutions will engage in strategic behaviour and
23 activities in which they enjoy some form of advantage over their competitors. Universities will attempt
24 to maximize the strategic fit between their institutional resources and the opportunities and needs in
25 their socioeconomic context when developing their third mission profiles. Consequently, different
26 university TTOs will be charged with different missions, and so their mission statements will not and
27 should not be identical.
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41 *TTO governance typologies*

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43 As well as defining the mission statement of its TTO, the university will also define the relationship of
44 the TTO with other university substructures (Brescia et al., 2016). We propose that the positioning of
45 the TTO within the broader organizational structure of the university should reflect and support the
46 activities in which the TTO engages. In other words, the mission statement and the TTO's structural
47 position should be aligned if there is to be effective knowledge transfer.
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Several TTO governance typologies exist (Brescia et al., 2015; Schoen et al., 2014). Initially, researchers considered TTOs to be centralized and hierarchical structures, embedded at the central level of the university (Link and Siegel, 2005). However, others have argued that TTOs can take a variety of organizational forms, defined predominantly by the degree of autonomy granted by the university (Markman et al., 2005). For example, Huyghe et al. (2014) constructed a typology that suggested three TTO structures: embedded in the traditional university structure, a non-profit research foundation, or a for-profit venture extension. However, these typologies focus only on the physical structure and governance model of the TTO.

In contrast, Schoen et al. (2014) present a typology that is informed by the *activities* in which the TTO engages. This typology is shown in Table 1, in which four TTO structures are identified, categorized by four structural dimensions.

Table 1 about here

However, the typology suggested by Schoen et al. (2014) does not expressly link the TTO's structure and activities to the mission statement. Yet there should be a mutually beneficial outcome if these two antecedents are aligned. The mission statement of the TTO should determine the activities it undertakes and the TTO's position within the university governance structure. The optimal design of a TTO is context- and time-specific; consequently, each university must take into account the TTO's specific goals and characteristics, as well as environmental factors, when organizing its technology transfer (Schoen et al., 2014).

TTO maturity

The third antecedent characteristic we consider is TTO maturity. This is a concept constructed by Secundo et al. (2016) and de Beer et al. (2017) (see Appendix A). The TTO maturity concept categorizes TTOs based on a range of non-monetary and intangible indicators (including assets, resources and proxies for process capabilities) across six categories of activity:

- i) human resources – essentially staff skill sets;
- ii) IP strategy and policy – the institutional support given to technology transfer;

- iii) networking – the efforts the TTO expends to build relationships *within* and across the university;
- iv) university–industry links – the efforts the TTO makes to build bridges with industry and organizations external to the university;
- v) technology –the TTO’s sensitivity to the stage of development of the technology being disclosed as well as the academic merit of the discloser; and
- vi) issues relating to the TTO’s organizational design and structure – size, age and surrounding support functions (e.g., the presence of a medical school or business school).

In combination, these resources and assets are weighted and combined to produce eight ‘maturity levels’ to which a TTO may be assigned (see Table 2):

Table 2 about here

- Level 1 is the ‘awareness’ stage and refers to newly established TTOs.
- Levels 2 and 3 refer to a TTO which is in the process of defining the activities in which it will engage.
- Levels 4 and 5, the ‘managed’ stages, refer to a TTO that is proactively engaging in technology transfer.
- Levels 6 and 7, the ‘integrated stages’, refer to a TTO that is supported by the university from executive to operational staff level.
- Level 8, the ‘sustained’ stage, refers to a TTO that has expertise in how to engage in knowledge (not just technology) transfer activities in a holistic, coherent and sustained manner.

Data and methodology

For this paper, the TTO maturity measure was translated into an online questionnaire which employed Likert scales to measure the presence (5) to absence (0) of several intangible indicators in the six categories of activity identified above (see Appendix A). We used universities’ webpages to identify their associated TTO. We then approached senior staff in the TTOs by email to complete the questionnaire online. The questionnaire was sent to 234 universities across Europe (118 in Continental Europe, and 116 in the UK) during June to December 2016, with at least one reminder during this period. Responses were received from 54 TTOs. The returned questionnaires were used to calculate a weighted average of the relative presence (or absence) of activity in each of the six activity categories for each respondent university’s TTO. These were then organized into the bands identified in Table 2, and assigned to a corresponding maturity level reflecting the efficiency of the university-specific TTO (de Beer et al., 2017).

Of the 54 questionnaire respondents, 19 indicated their willingness to undertake follow-up interviews. Interviewees came from Belgium (3), Bulgaria (1), the Czech Republic (4), Denmark (1), Estonia (1), The Netherlands (1), Sweden (1), Switzerland (1) and the UK (6). The interviews gathered detailed information about the range and types of activities the TTO was engaged in as well as a deeper understanding of the underlying meaning, intent and rationale of the content of their mission statements. Interviews were conducted in a semi-structured manner with a common set of questions, while allowing interviewees to elaborate on their answers and enabling us to ask additional probing questions. Generally, the interviews lasted 30 minutes and were conducted face-to-face at the respondent university or via a Skype call. The questionnaire respondent and subsequent interviewee was usually someone holding a middle-management position in the TTO, although they were not necessarily the same person in both instances: due to work commitments, interviews were sometimes deputized by the questionnaire respondent to a colleague.

Findings

The maturity levels for all 54 questionnaire respondents are reported in Appendix B. The maturity levels among the 19 interviewed TTOs ranged between levels 4 and 5 (the managed stages) out of a possible 8 (see Table 3, Column 1).

Table 3 about here

The interviews identified that the mission statement content of university TTOs had three objectives: commercialization, impact and relationship building. However, for each TTO, one or other of these objectives was more dominant in the TTO strategy (Table 3, Column 2). Additionally, the interviews support studies outlined above in the literature review section, in that TTOs attempt to support each objective with differentiated activities (Table 3, Column 3):

- *commercialization* is supported through IP protection, licensing and spin-off company creation;
- *impact* is supported through research outputs, knowledge transfer and contributions to regional development; and
- *relationship building* is supported through supporting/developing research contracts, specialized consulting to industry and collaboration for the development of research.

The interviews also allowed us to confirm the TTO's position with respect to the broader university organization and to identify it as one of three TTO structural types (Table 3, column 4):

- *Internalized*. The TTO is a centralized department or office within the university, but functions independently from other university substructures. This means that the TTO is physically and culturally close to all the other resources of the university (legal team, management team) as well as faculties and academic departments, which enables it to build strong internal relationships in the university and to leverage research contracts to create university–industry links.

- *Externalized.* The TTO is established as a company outside the university structure per se, yet is wholly owned by it. It is more autonomous (has responsibility for resolving legal issues, marketing, customer relationship management, etc.) and may be more able to take on more risk and seek to engage more proactively in developing commercial ventures.
- *Hybridized.* The TTO is a centralized office, but is supported by other university substructures (university-level marketing and legal sections, etc.) and IP scouts (faculty-level IP scouts with more specialized knowledge) or both. These other substructures may be internalized within the university or independent (external) third parties – e.g., the university may have a legal department itself, or may subcontract out such work to an independent legal firm.

Interesting trends emerge from the data in Table 3. Just over half of the interviewed TTOs (10 out of 19) have strong, clear alignment between their dominant mission statement and their activities.

The dominant objective of seven of the TTOs is commercialization; four of these conduct only those activities that are strongly aligned with this objective, and three of them are held externally from the rest of the university structure and are also the more mature (level 5) TTOs. Only the Danish university TTO with level 4 maturity is internalized within the university structure.

Nine TTOs have relationship building as their dominant objective. Four conduct only those activities that are strongly aligned with this; of these, three (all level 4 maturity) are held as externalized structures, and the fourth (level 5 maturity) is held in an internal structure. It is likely that in either case the organizational position is well aligned with the mission statement and activities, depending on whether the TTO, at the time of the questionnaire and interview, was focused on developing stronger internal relationships or on external relationship building.

Only three TTOs identify impact as the dominant objective of their mission statement – all are in the lower, level 4 maturity category. Two undertake only activities that strongly align with this objective, although they have different positions within the university organizational structure.

Nine of the 19 TTOs, despite having a dominant focus within their mission statement, pursue activities that are broader than that focus would suggest. Organizationally, they all exist in a hybrid

structure; that is, despite explicitly identifying a dominant mission statement objective for their office, the variances in the actual activities undertaken suggest that these are not as aligned to the dominant objective as they ought to be. We offer three interpretations of this outcome: a) the position of the TTO in a hybridized structure leads to an unfocused approach due to multiple demands on it from across the university's substructures; b) the TTO is actually deliberately addressing multiple objectives because it perceives multiple opportunities in the external environment, and is enabled by its position in a hybridized structure to pursue them, but it has not reflected this in its mission statement; or c) the university is in a transition period moving between one dominant focus to another, but the mission statement has either been written an advance of this transition or lags behind it.

In all cases, if the TTO's performance is assessed against measures associated with a particular dominant objective, it is likely a TTO with diffuse activities will be regarded as underperforming, whichever interpretation is appropriate. Due to difficulties concerning the availability of data about the third stream activities universities undertake (Rossi and Rosli, 2014; Molas-Gallart et al., 2002; Molas-Gallart and Castro-Martínez, 2007), we are unable to test for this assumption at this juncture. Nevertheless, irrespective of whether the mission statement should be used more forcefully as a focal device for a TTO's activities, or whether the statement itself needs to be revised to reflect the breadth of the activities so as to generate more interest from both internal and external parties, revisiting the mission statement seems necessary to ensure alignment between it and the TTO's activities and position within the university governance structure.

For the TTOs in hybrid-type structures at the higher levels of maturity, it is tempting to interpret this as a deliberate structural choice – as an attempt to build relationships internally and/or to pursue externally-oriented commercial objectives by drawing on other parts of the university structure simultaneously. On the other hand, for the less mature TTOs, it is tempting to interpret the hybrid structure as reflecting a misalignment between the dominant objective in the mission statement and the activities the TTO undertakes. Of course, the adoption of a hybrid structure by the more mature TTOs may also reflect misalignment, just as its adoption by less mature TTOs may be a deliberate strategic

choice to pursue more than one key objective. Due to the small sample size, our findings must be interpreted with caution. Similarly, it is difficult to be conclusive about the appropriate governance structure for a TTO for which the pursuit of impact is a dominant objective, as there are only two cases of universities with impact as their dominant objective in our sample and each has a different type of TTO.

Recommendations

The intent of this paper is to identify antecedent characteristics of the better practices employed by developed countries’ university TTOs that TTOs in developing countries might seek to emulate. The literature review above suggests that a clearly defined mission statement, and an organizational structure that reflects and supports the activities in which the TTO engages, are among the antecedents that are conducive to better practices. This paper seeks to align these three TTO characteristics to derive a typology of TTOs. This would be useful to TTOs in developing countries in the early stages of their formation and would help them to avoid potential mistakes associated with a lack of alignment that this study of developed nation TTOs identifies.

The limited numbers of the responses to our questionnaire and the subsequent interviews are clearly a limitation for our findings and recommendations. As such, the clear typology of TTOs that was our ambition has not been achievable. Nevertheless, with that caveat, we offer the following suggestions to developing country TTOs in their early stages of development.

Early-stage TTOs should look at their university’s characteristics in relation to the local environment to see how the two can be brought to a mutually beneficial position: in other words, what is there within the university that could be leveraged to benefit local industry and society? Is there a strong engineering faculty, a management school, or a medical school? Is the university performing research that is highly scientific and blue-sky, or does its research profile have potential application and commercial relevance for business and non-commercial relevance to society? Is this research contribution leading to radical innovation in the form of new products and processes, or can knowledge

transfer based on the research lead to incremental improvements? The outcome of such considerations should inform the dominant focus of the mission statement for the TTO, as it should signal the university's potential for the commercialization of technology, its ability to build networks for the transfer of knowledge and exchange of knowledge more broadly, or its ability to impact on business practice and policymaking.

It would probably be best if just one dominant focus could be identified for the early-stage TTO, as this would help ensure that resources were devoted to the pursuit of activities most strongly associated with the mission focus. With multiple foci which are treated with equal priority within the mission statement, it is likely that too many activities will be pursued simultaneously and therefore learning-curve experiences in the TTO will be slower, and any potential economies of scale/scope will be suboptimal. Additionally, with multiple foci, the performance of the TTO will be harder to measure and may be more ambiguous. A lack of clear benefit may lead to strategic decisions in a resource-strapped university to cut back on TTO funding (and devote the money to the less uncertain objective of raising teaching resources and quality, for example).

With a clear objective and having identified the appropriate activities, the TTO can employ the maturity model tool developed by Secundo et al. (2016) and used in this paper to ascertain its current level of maturity and the level of maturity it would like to attain, as identified by comparison with a specific TTO from a developed country. Looking at the state of its current resources, assets and capabilities in each of the six areas identified in this tool, and where these need to be for the TTO to reach its desired level of maturity, may help it make its case to senior university management for more investment in certain areas.

Having identified the dominant objective and the activities the TTO needs to engage in to pursue it, the university must position the TTO within its broader governance and organizational structure to enable it to undertake those activities. If the dominant objective is commercialization, then an externalized structure for the TTO might enable it to be more risk-taking and afford it the freedom to pursue external opportunities by liberating it somewhat from the bureaucracy associated with

internalized departments and offices. On the other hand, if the dominant objective is relationship building, the strategic approach needs to be clearly identified by the university so that the TTO will know where it should be focusing its efforts when building relationships. If the university perceives that it has latent potential to contribute to industry and society, the TTO needs to have a strong awareness of faculties' research strengths and current projects. Consequently, strong internal relationships are a prerequisite for an efficient search for external partners. Additionally, the TTO might be better received by other departments if it is known to be an integral part of the university. Alternatively, if the strategic approach of the university is to seek external opportunities that provide the basis for research projects within the university, then the TTO should focus on building external relationships prior to signalling to internal faculties and departments that such opportunities exist. This might be better achieved if the TTO is positioned as an external agent to the university structure so that it is perceived by businesses more as a commercial venture than as an academic agent.

Finally, because we do not measure the individual relative performance of our developed country TTOs against each other, we cannot say definitively that adopting a hybrid organizational structure for the TTO position leads to poorer outcomes. Indeed, we have suggested three potential implications of the misalignment of hybrid structures and dominant foci in mission statements, only one of which is clearly negative. Had universities confirmed that they did not have a single dominant objective in their mission statement, but rather had multiple objectives, the alignment of multiple activities in a hybrid organizational structure might have been entirely appropriate. However, based on commonly received wisdom, and in support of Morpew and Hartley (2006), aligning a single dominant objective, its corresponding activities and a conducive structure would seem to be an advisable target for early-stage TTOs in developing countries.

Conclusion

Whilst our ambition to derive a novel typology of TTOs that would align their mission statement objective with their activities and structure and their maturity level was not achieved, our research suggests that this is an area ripe for further investigation. The findings highlighted from our sample suggest that, even among developed country TTOs to which developing country TTOs look as exemplars of better practice, there is considerable variety in the way these three antecedents are aligned. Unfortunately, we have not been able to identify which combinations might lead to better TTO performance. Whilst there is difficulty in finding metrics and proxies for the range of knowledge transfer activities university TTOs are engaged in, particularly with respect to internationally comparable data, there is a growing opportunity to measure performance outcomes for individual countries (e.g., England – see Rossi and Rosli, 2014)). In future work, it may be possible to apply this study to the TTOs of universities in a single country and to assess them in terms of their relative performance outcomes.

For developing country TTOs, we suggest that the pursuit of a single dominant objective and the corresponding alignment of activities and structure would be best, given their early stages of development. We also suggest that, if a developing country TTO can identify a *specific* TTO which they aspire to emulate, they can employ the maturity model tool, look at the dominant objective of that TTO, analyse the activities it undertakes and its position in relation to the broader university structure, and then use these as a template for its own development, while remaining sensitive to the differences in the national, institutional and organizational contexts.

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Appendix A: The self-assessment tool along with relative weighting.

Rank	Likert scale	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Weight
	Human resource						
1	At least one staff member has the expertise to manage the licensing portfolio as a set of options						80%
2	TTO has sufficient number of staff						78%
3	At least one staff member has marketing experience						72%
	IP strategy and policy	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	A clear, transparent and consistent vision for technology transfer, with strategic goals and priorities						83%
2	Frequent and reciprocated involvement with faculty						77%
3	Sufficient resource allocation to TTO						75%
4	Provide education to overcome informational and cultural barriers between TTO and Faculty						65%
5	Incentives for faculty to disclose						64%
6	Royalty shares for faculty						61%
7	Incentives for TTO staff						55%
	Networking	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	TTO has personal relationships with faculty						79%
2	Formal and/or informal networking between faculty and TTO						70%
3	TTO facilitates formal and/or informal networking between scientists						62%
	University–industry links	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	TTO understands needs of industry						89%
2	TTO facilitates formal and/or informal networking between faculty and industry						80%
3	Provide education to overcome informational and cultural barriers between TTO and industry						64%
	Technology	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	Most technologies disclosed to TTO are not at an early stage						54%
2	Most faculty members who disclose are professors						33%
	Organizational design and structure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
1	A business incubator is available for faculty						67%
2	TTO has been established for 10 years or more						56%
3	TTO has a decentralized management style						53%
4	University has a medical school						51%
5	TTO is positioned externally to the university						50%
6	University is publicly owned						39%

Appendix B: Maturity levels of 54 questionnaire respondents.

Country	Maturity level	Country	Maturity level
Belgium 1	5	UK 8	4
Belgium 2	5	UK 9	4
Estonia	5	UK 10	4
Greece	5	UK 11	4
Sweden 1	5	UK 12	4
Switzerland	5	UK 13	4
UK 1	5	UK 14	4
UK 2	5	UK 15	4
UK 3	5	UK 16	4
Belgium 3	5	UK 17	4
Sweden 2	5	UK 18	4
UK 4	5	UK 19	4
UK 5	5	Austria 1	3
UK 6	5	Austria 2	3
France	5	Belgium 5	3
Belgium 4	4	Greece	3
Czech Republic 1	4	Italy	3
Bulgaria	4	Netherlands 3	3
Czech Republic 2	4	UK 20	3
Czech Republic 3	4	Germany 5	3
Czech Republic 4	4		
Czech Republic 5	4		
Denmark	4		
Finland	4		
Germany 1	4		
Germany 2	4		
Germany 3	4		
Germany 4	4		
Netherlands 1	4		
Netherlands 2	4		
Poland	4		
Romania	4		
Spain	4		
UK 7	4		

Table 1. Activity-based TTO typology.

Structure	Description	Structural dimension	Description
The classical TTO	Serves one university exclusively and is integrated into its administrative structure	Level of autonomy (dependent or independent)	The influence of different levels of autonomy granted to the TTO on new venture creation and licensing strategies.
The autonomous TTO	Has a significantly higher degree of autonomy from the university's administration	Degree of task specialization (ranges from generalization to specialization)	Defines the distribution of tasks within the organization. The function of a TTO is to act as an intermediary between the university and industry. This role is multifaceted, with three main activities: (1) research funding and services, (2) IP management (including the selection of inventions and out-licensing negotiations), and (3) spin-out services.
The discipline-integrated Technology Transfer Alliance (TTA)	Serves the technology transfer activities of several universities and is organized outside a university's administrative structure	Degree of exclusivity (exclusive or non-exclusive)	Whether a TTO serves more than one university, as opposed to having an exclusive relationship with one institution.
The discipline-specialized TTA	Is focused on one academic discipline and, like the discipline-integrated TTA, serves several universities	Degree of discipline specialization (ranges from discipline-specialized to discipline-integrated)	Discipline specialization means that decisions regarding technology transfer are taken at the departmental level and are focused on one specific scientific discipline. In contrast, a discipline-integrated TTO structure implies that decisions about technology transfer activities are taken at the institutional level with the same rules and processes for all the departments.

Source: Schoen et al. (2014).

Table 2. Maturity model.

Weighted score	Description of activity	Maturity level
0–15.57	Awareness stage	1
15.58–25.95	Defined early stage	2
25.96–36.33	Defined late stage	3
36.34–46.71	Managed early stage	4
46.72–57.09	Managed late stage	5
57.10–67.47	Integrated early stage	6
67.48–77.84	Integrated late stage	7
77.85	Sustained stage	8

Source: de Beer et al. (2017).

Table 3. Survey and interview data for 19 TTOs in Continental Europe and the UK.

Country	Maturity level	Dominant focus of mission statement	Activities	Type
UK 1 ^a	5	Commercial	IP protection Licensing Spin-off company creation	External
Switzerland ^a	5	Commercial	IP protection Licensing Spin-off company creation	External
UK 2 ^a	5	Commercial	IP protection Licensing Spin-off company creation	External
Belgium 1 ^a	5	Relationships	Research contracts Establishing university–industry links	Internal
Sweden	5	Commercial	IP protection Licensing Spin-off company creation <i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
Belgium 2	5	Commercial	IP protection Licensing Spin-off company creation Research contracts Establishing university–industry links	Hybrid
Estonia 1	5	Relationships	Research contracts Establishing university–industry links IP protection Licensing Spin-off company creation	Hybrid
UK 3	5	Relationships	Research contracts Establishing university–industry links <i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
Denmark ^b	4	Commercial	IP protection Licensing Spin-off company creation	Internal
Belgium 3 ^b	4	Relationships	Research contracts Establishing university–industry links	External
Bulgaria ^b	4	Relationships	Research contracts Establishing university–industry links	External
Czech Republic 4 ^b	4	Relationships	Research contracts Establishing university–industry links	Internal
Czech Republic 2 ^b	4	<i>Impact</i>	<i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
UK 6 ^b	4	<i>Impact</i>	<i>Knowledge transfer</i> <i>Regional development</i>	Internal
Netherlands	4	Commercial	IP protection Licensing Spin-off company creation Establishing university–industry links <i>Regional development</i>	Hybrid
Czech Republic 3	4	Relationships	Research contracts Establishing university–industry links <i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
Czech Republic 1	4	Relationships	Research contracts Establishing university–industry links <i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
UK 4	4	Relationships	Research contracts Establishing university–industry links <i>Knowledge transfer</i> <i>Regional development</i>	Hybrid
UK 5	4	<i>Impact</i>	<i>Knowledge transfer</i> <i>Regional development</i> Research contracts Establishing university–industry links	Hybrid

Note: Bold type – activities associated with the relationship-building objective; normal type – activities associated with the commercialization objective; Italic – activities associated with the impact objective. ^a Maturity level 5 TTOs with clear alignment between

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stated dominant focus and the TTO’s activities. ^b Maturity level 4 TTOs with clear alignment between stated dominant focus and the TTO’s activities.

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